<Advanced Research Center for Beam Science> Particle Beam Science

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- Particle Beam Science -

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Prof
NODA, Akira
(D Sc)

Assoc Prof
IWASHITA, Yoshihisa
(D Sc)

Assist Prof
SOUDA, Hikaru

Techn
TONGU, Hiromu

Res
FUJISAWA, Hiroshi
(D Sc)

Lecturer (pt)

YAMADA, Satoru (D Sc)
Gunma University Heavy Ion Medical Center

Students

ITOH, Hiroyuki (D3)
ICHIKAWA, Masahiro (D1)
NAKAO, Masao (D1)
SUGIMOTO, Takanori (M2)
YAMADA, Masako (M2)
WAKITA, Akihisa (M2)

Technician(pt)

KAZAMA, Ichiro

Visitors

Dr JAMESON, Robert A — Goethe University, Germany, 8 April–6 June 2008
Dr GRIESER, Manfred — Max Planck Institute, Germany, 17–29 November 2008

Scope of Research

The Following Subjects are being studied: Beam dynamics related to space charge force in accelerators: Beam handling during the injection and extraction processes of the accelerator ring: Ultra-low Emittance state of a proton beam created by the electron cooling: Laser cooling of Mg^+ ion beam: Compression of the energy spread of laser-produced ion beams by an rf cavity for phase rotation: Research and development of permanent quadrupole magnets for final focusing of International Linear Collider (ILC): Development of electron-cyclotron resonance (ECR) ion source for small neutron source.

Research Activities (Year 2008)

Publications

Wakasugi M, Noda A, Shirai T et al., Novel Internal Target for Electron Scattering off Unstable Nuclei, *Phys. Rev. Lett.*, **100**, 164801 (2008).

Tanabe M, Ishikawa T, Nakao M, Souda H, Ikegami M, Shirai T, Tongu H, Noda A: Longitudinal and Transverse Coupling of the Beam Temperature, *Appl. Phys. Express*, **1**, 028001 (2008).

Fujimoto T *et al.*: Formation and Fast Extraction of a Very Short-bunched Proton Beam for the Investigation of Free Radicals, *Nucl. Instrum. Meth.*, **A588**, 330-335 (2008).

Iwashita Y *et al.*: Variable Permanent Magnet Sextupole Lens for Focusing of Pulsed Cold Neutrons, *Nucl. Instrum. Meth.*, **A586**, 73-76 (2008).

Tajima Y *et al.*: Reduction of Skin Effect RF Power Loss by a Thin Conductor Foil, *Jpn. J. Appl. Phys.*, **47**, 4765-4768 (2008).

Iwashita Y *et al.*: Development of High Resolution Camera for Observations of Superconducting Cavities, *Phys. Rev. ST Accel. Beams*, **11**, 093501 (2008).

Souda H *et al.*: COD Correction for Laser Cooling at S-LSR, *Nucl. Instrum. Meth.*, **A597**, 160-165 (2008).

Presentations

Souda H *et al.*, Alignment of S-LSR, 10th International Workshop on Accelerator Alignment (IWAA08), 12 February 2008, Tsukuba, Japan.

Iwashita Y *et al.*, Development of a High Resolution Camera and Observations of Superconducting Cavities, 11th European Particle Accelerator Conference (EPAC'08), 25 June 2008, Genoa, Italy.

Noda A *et al.*, Present Status of Beam Physics Research using Accelerator Facility of ICR, Kyoto University, The Fifth Annual Meeting of Particle Accelerator Society of Japan/The 33rd Linear Accelerator Meeting, 6 August 2008, Hiroshima, Japan.

Grants

Noda A, Creation of Innovation Centers for Advanced Interdisciplinary Research Areas: Photo-Medical Valley,

Laser Cooling of a Mg^+ Ion Beam at S-LSR

Laser cooling experiments of $^{24}Mg^+$ ion beams with the kinetic energy of 40 keV have been carried out at an ion storage and cooler ring, S-LSR. A transition between $3s^2S_{1/2}$-$3p^2P_{3/2}$, corresponding to a laser wavelength of 280nm at laboratory frame is utilized. A laser with this wavelength is attained by a frequency doubler applied to the output from a ring dye laser pumped by a Nd:YVO_4 laser.

Figure 1 shows the dependence on the cooled ion number of the equilibrium longitudinal temperature realized by the beam cooling with the use of a co-propagating laser and an induction deceleration [1]. With cooling, the relation between particle numbers N and longitudinal temperatures $T_{\|}$ is measured as $T_{\|} = 0.14N^{0.32}$. The attained lowest longitudinal temperature, 3.6 K, is limited by higher temperature of transverse directions, which are weakly coupled with that of longitudinal direction by an intra beam scattering.

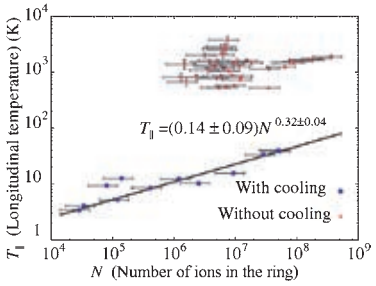

Figure 1. Equilibrium longitudinal temperature of the beam cooling for various numbers of circulating ions.

According to this result, it is necessary to reduce temperature for further cooling. Theoretically, transverse laser cooling is to be achieved by coupling of longitudinal and transverse degrees of freedom by synchro-betatron resonance. In Figure 2, momentum spreads after application of the longitudinal beam cooling for the bunched beam with various synchrotron tunes are shown. In this figure, sharp peaks of momentum spreads appear for the conditions where synchrotron tune and horizontal betatron tune, ν_s and ν_x, are 0.064 and 2.065 or 0.057 and 2.054. This result means longitudinal cooling rates are reduced when the resonance condition is satisfied. It is considered as an indication of longitudinal and transverse coupling. Further experiments to demonstrate transverse cooling by observing the transverse size reduction associated to a longitudinal beam cooling is now under preparation.

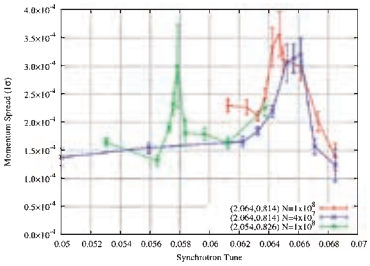

Figure 2. Momentum spreads of laser-cooled bunched ion beams for various synchrotron tunes.

Proof of Principle Experiment of Electron Nucleus Scattering with use of SCRIT (Self-Confining Radioactive Isotope Ion Target) installed into KSR

With the use of an electron storage ring, KSR, the studies of the structure of nucleus trapped into an ion trap: SCRIT (Self-Confining Radioactive Isotope Ion Target) set in a straight section of KSR as shown in Figure. 3 has been performed in these a few years by collaboration with a group from RIKEN. Recently the principle of such a scheme to investigate the structure of the nucleus detecting the scattered particles by an electron-nucleus scattering has been successfully demonstrated for stable ions as ^{133}Cs, although the final aim of such a scheme is to be applied for unstable nuclei [2].

Figure 3. An overall view of an electron storage ring, KSR, where the SCRIT is installed.

[1] Tanabe M *et al.*, *Appl. Phys. Express* **1**, 028001 (2008).
[2] Wakasugi M *et al.*, *Phys. Rev. Lett.* **100**, 164801 (2008).

Special Coordination Funds for Promoting Science and Technology, 1 June 2007–31 March 2010.

Iwashita Y, Application and Development of Super Strong Permanent Magnet Especially for Linear Collider and Neutron Optics, Grant-in-Aid for Scientific Research, (A) (1), 1 April 2006–31 March 2009.

Iwashita Y, Development of Satellite Compact Pulse Neutron Source, Joint Development Research at High Energy Accelerator Research Organization (KEK), 1 April 2007–31 March 2008.

Souda H, Three-dimensional Crystalline Beam by Laser Cooling and Beam Orbit Control, Grant-in-Aid for Scientific Research for JSPS Fellow, 1 April 2007–31 March 2009.

Award

Yamada M, Poster Prize, Development of the Permanent Magnet Sextupole Lens for Focusing of Pulsed Neutron Beam, 8th Annual Meeting of the Japanese Society for Neutron Science, 2 December 2008.